NESDIS Snowfall Rate (SFR) Product Training Session

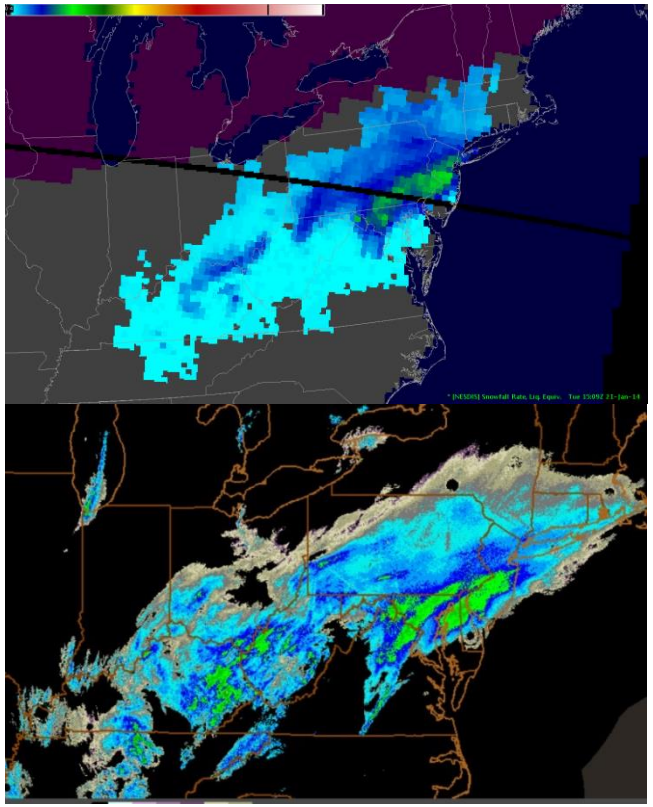
Huan Meng, Ralph Ferraro, Brad Zavodsky

NOAA/NESDIS

NASA/SPoRT

Snowfall Rate Product

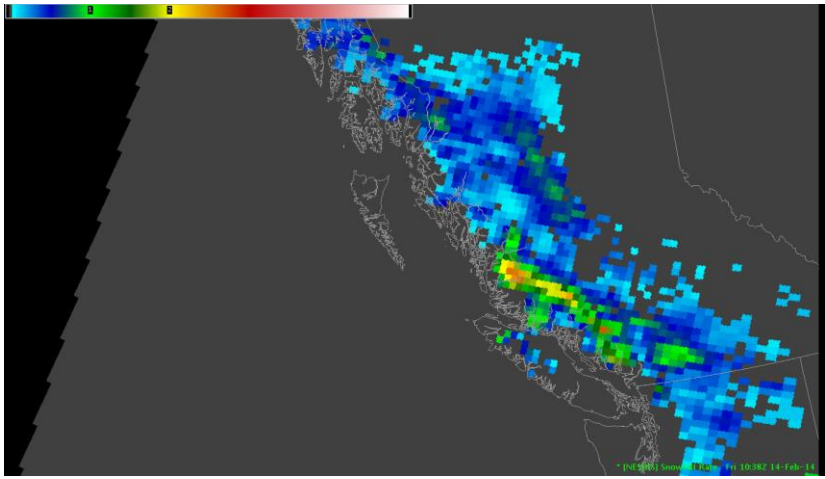
- Satellite retrieved liquid equivalent snowfall rate (SFR) over land
  - Liquid to solid ratio is dependent on the local climatology and environmental conditions such as surface air temperature and temperature profile
- SFR uses data from polar-orbiting microwave sensors: four Advanced Microwave Sounding Unit-A (AMSU-A)/Microwave Humidity Sounder (MHS) pairs and one Advanced Technology Microwave Sounder (ATMS) aboard NOAA POES, EUMETSAT Metop, and S-NPP satellites, respectively

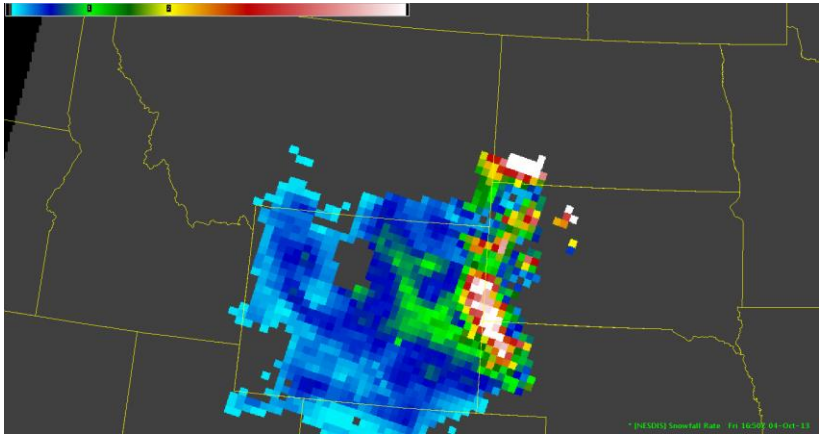


  - Generally, each satellite passes a location twice per day at mid-latitudes, more in higher latitudes. Each satellite's passes are about 12 hours apart providing up to ten daily SFR estimates, 5 morning; 5 afternoon overpasses (up to 50 daily estimates near the poles).
- SFR resolution is 16 km at satellite nadir with lower resolution at limbs
- Maximum liquid equivalent snowfall rate is 0.2 in/hr; minimum is 0.0012 in/hr

Product Applications

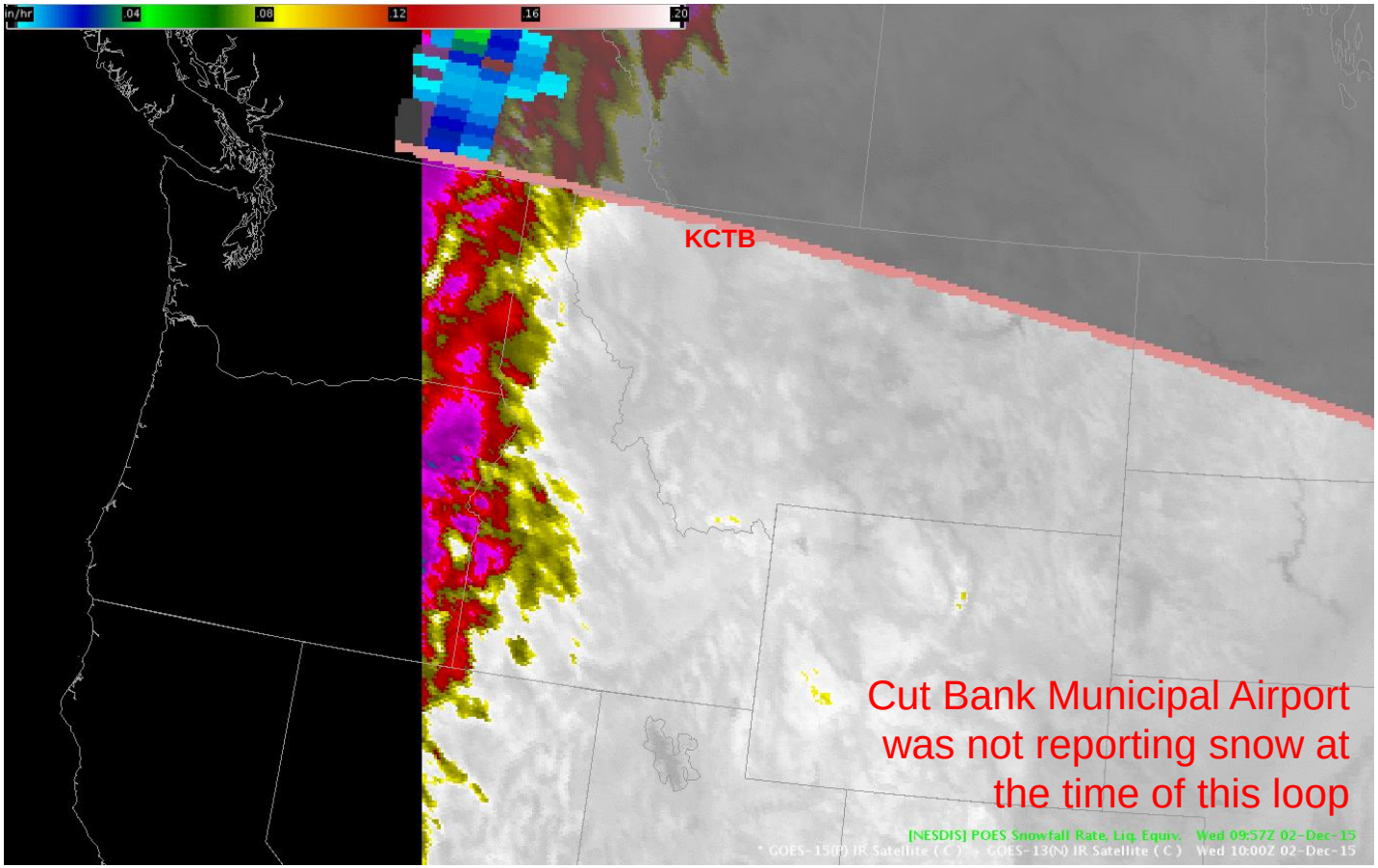
- Identify in-cloud snowstorm extent and the location of the maximum intensity within the storm
- Provide quantitative snowfall information to complement snowfall observations or estimations from other sources (stations, radar, GOES imagery data etc.)
- Fill observational gaps in mountains and remote regions where radar and weather stations are sparse or radar blockage and overshooting are common
- Locate snowstorms at higher latitudes where the quality of the subjective GOES IR and VIS imagery data deteriorates





- Track storms and derive trending information (e.g. strengthening or weakening of the storm) by pairing with radar and/or GOES IR/VIS/WV images

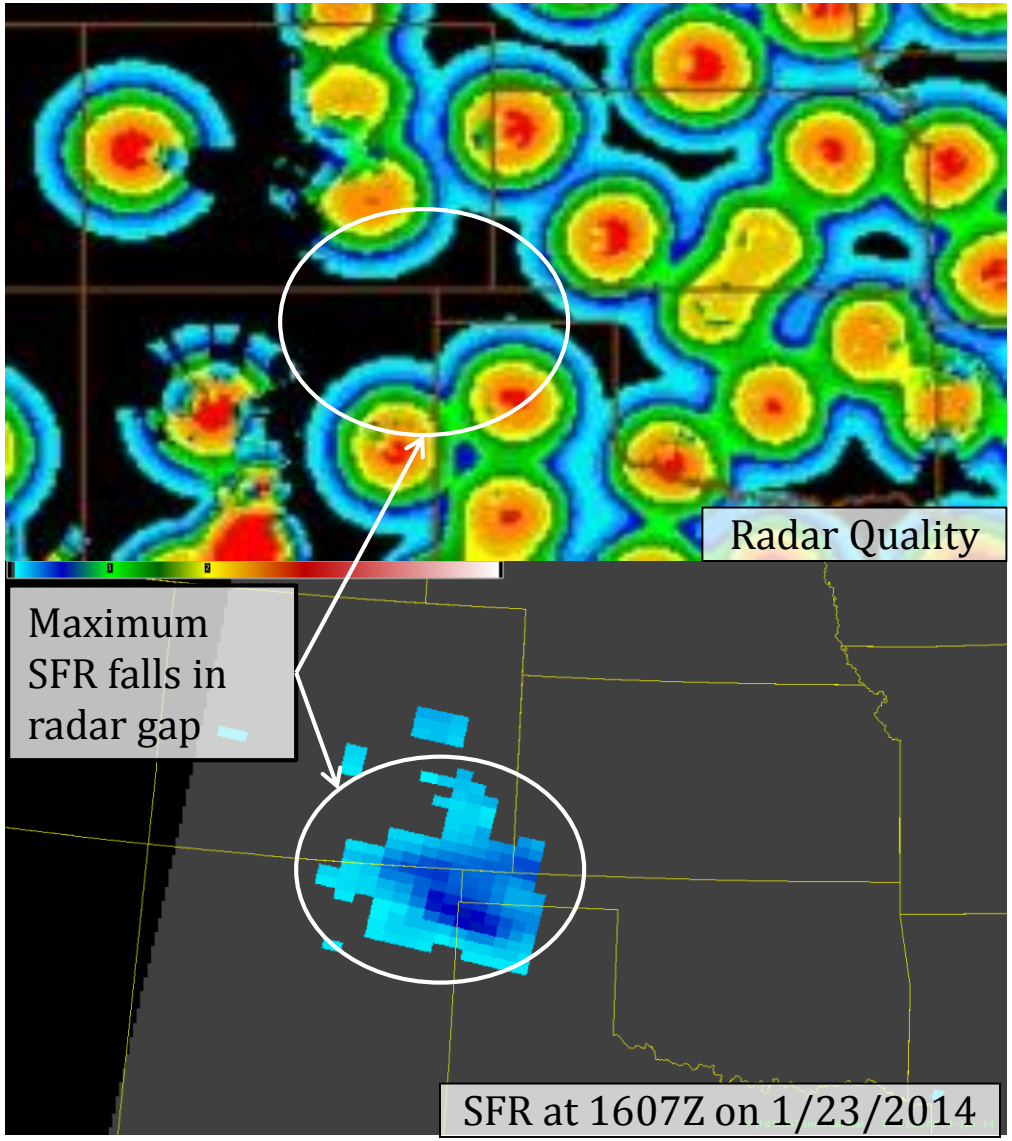
Use Case 1 – Tracking Snowstorms



- SFR is complementary to radar and GOES data
- SFR makes it easy to identify edge of snowfall and area of maximum intensity
- The movement and strength of a feature identified in SFR can be tracked using GOES imagery or radar between SFR overpasses

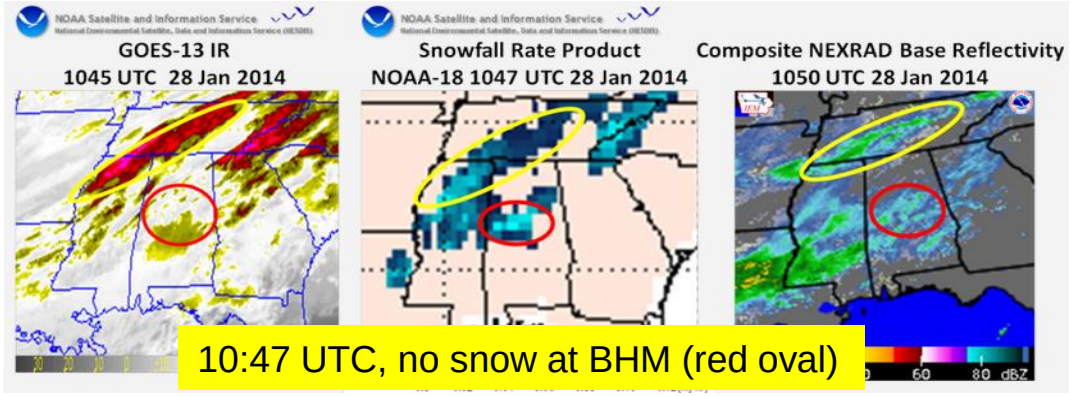
Use Case 2 – Filling Radar Gaps

ABQ WFO on January 23, 2014: The areal coverage of the product was very good compared with the observations. There is very limited radar coverage in that area and it filled in the gap from northeastern NM to southeastern CO well. We were already issuing nowcasts for the snowfall but the product helped increase confidence in the area where the snowfall was reported.



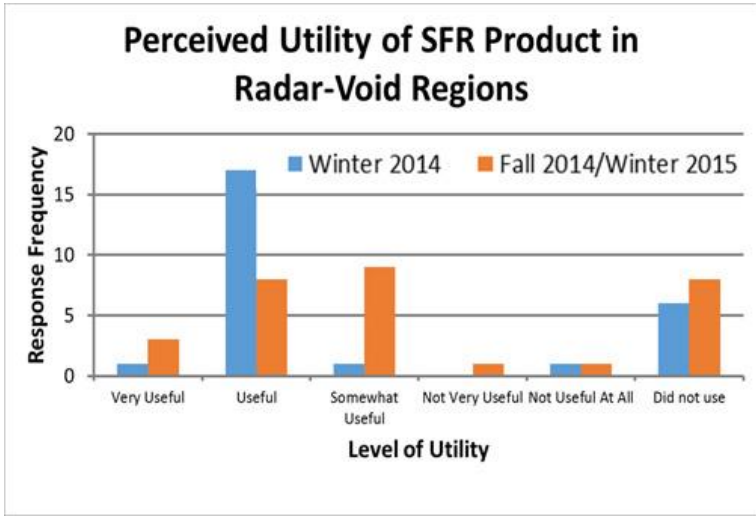
Use Case 3 – Short Term Forecasting

- Under the right conditions, SFR can be used as a short term forecast product
- In-cloud snow not reaching the surface can seed existing clouds to increase the likelihood of snow reaching the surface
- Example: Birmingham, AL surprise snow on Jan 28, 2014
  - At 1047 UTC, SFR showed snow in clouds but no snow was observed at surface in Birmingham; in-cloud seeding was occurring
  - At 1553 UTC, snowfall was reported at BHM and later intensified; SFR product, IR, and NEXRAD all reported snow by 1619 UTC
  - More details: https://nasasport.wordpress.com/2014/02/24/birmingham-alabama-surprise-snow-of-january-28-2014-or-was-it/



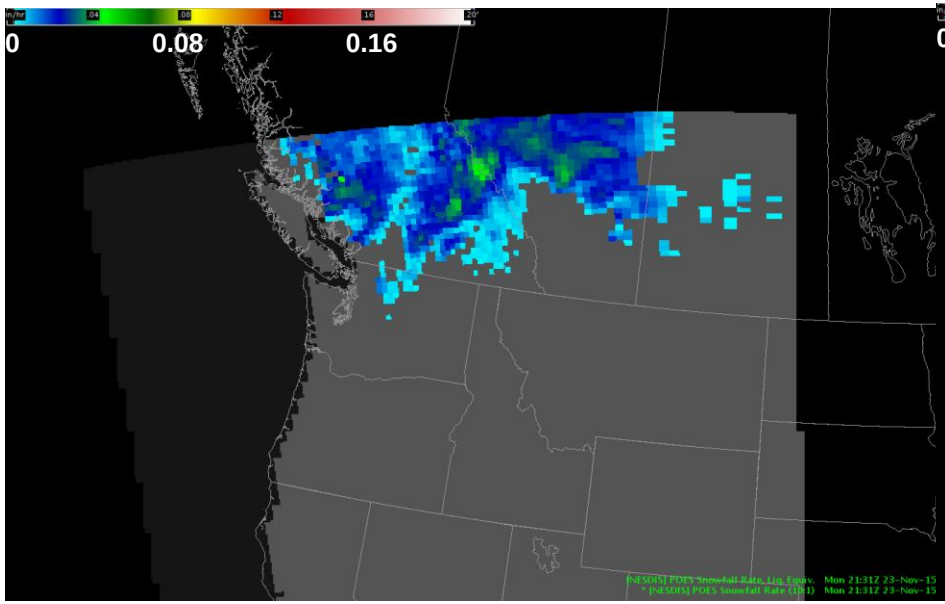
Review of Previous Assessments

- Outcomes of previous assessments:
  - 2014
    - Product latency (improved through use of direct broadcast observations)
    - 22ºF surface temperature threshold eliminated too much (modified detection algorithm to retrieve SFR above 7ºF)
    - Too much light snow not captured (reduced the minimum detection threshold to improve light snow detection)
  - 2015
    - Display issues in AWIPS-II (stabilized the installation instructions, added options for displaying solid SFRs, masking for too cold and over water)
    - Challenges remain with light snow (changes to snow detection algorithm implemented; in addition, recalibrated SFR against MRMS to reduce bias)
    - Unable to loop SFR product (created beta radar-satellite merged product; mSFR)

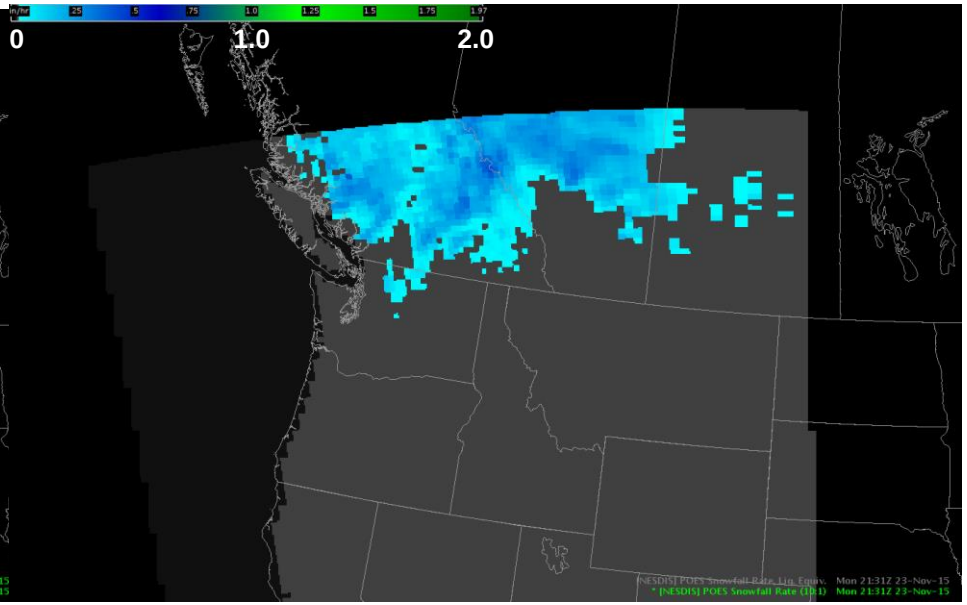


Improved Display in AWIPS-II

Liquid Equivalent mm/hr



10:1 Solid to Liquid Conversion (in/hr)



- Raw product is liquid equivalent precipitation
- User can select from three pre-fabricated solid to liquid ratio conversions (10:1, 18:1, and 35:1) based on knowledge of environment
- Areas too cold for SFR algorithm are masked in purple, ocean areas masked in dark grey, swath width denoted by light grey
- Procedures will be sent out to aid in faster product loading and combining with GOES imagery to highlight use for feature tracking

Improved Snowfall Detection

- Snowfall Detection (SD) improvement and validation
  - Parameters were adjusted to improve overall performance
  - SD algorithms were evaluated with CONUS in-situ data
  - About 50% of in-situ data is 'trace' snow - challenging to detect for satellite product

ATMS SD	POD (%)	FAR (%)	HSS	HSS Increase (%)
warm regime	41(39*)	10(10)	0.34(0.33)	3
cold regime	58(39)	11(6)	0.49(0.38)	29

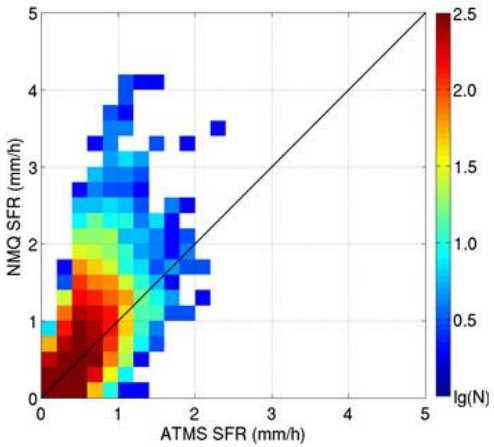
MHS SD	POD (%)	FAR (%)	HSS	HSS Increase (%)
warm regime	53(47*)	13(12)	0.38(0.36)	6
cold regime	41(38)	10(9)	0.32(0.31)	3

- Snowfall Rate (SFR) improvement and validation
  - Histogram matching with MRMS radar snowfall rate

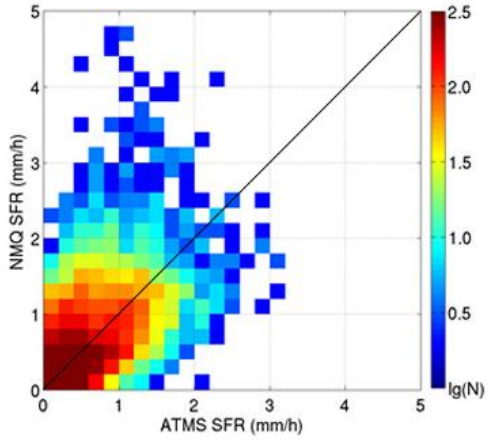
	Correlation Coe	Bias (mm/hr)	RMSE (mm/hr)
ATMS SFR	0.52(0.51*)	-0.07(-0.18)	0.55(0.55)
MHS SFR	0.49(0.52)	-0.28(-0.42)	0.72(0.75)

* Values in parentheses are the original statistics

Original SFR



Recalibrated SFR



What to be Aware of

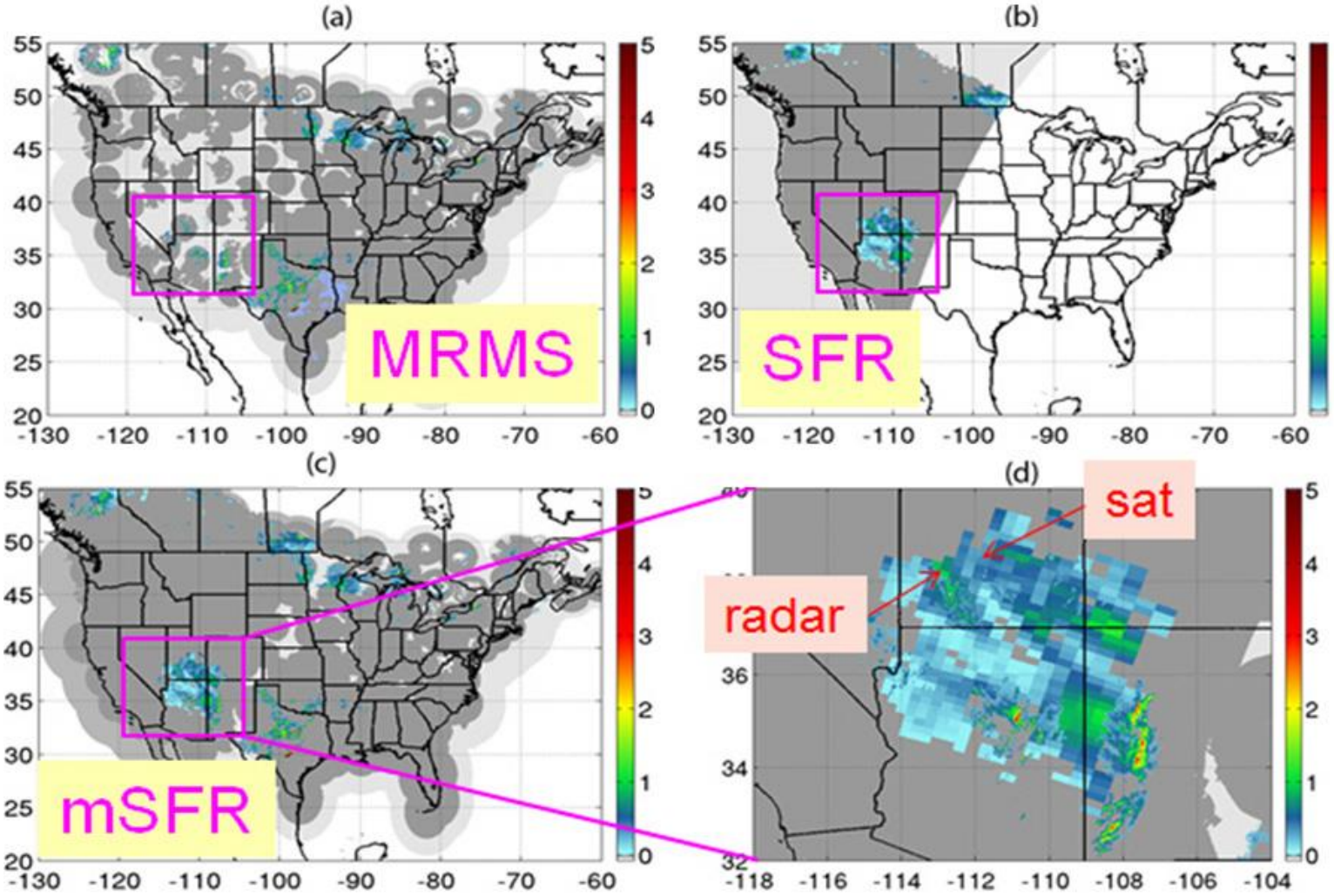
- Raw product measures liquid equivalent snowfall rate over land (estimations of solid snow are now included in the visualization; water is masked as grey in your display)
- Product is not retrieved where surface air temperature is below ~7°F (masked in purple in your display)
- Product represents snow in the atmosphere, so there usually is a time lag (average: 1~1.5 hours) between the retrieved SFR and the best correlated ground observation
- Algorithm reliance on GFS data means that model error may impact rain/snow detection
- The algorithm performs best for:
  - stratiform snow in non-shallow clouds
  - for mesoscale and synoptic scale systems
  - medium to heavy snowfall
- Polar orbiter data is not evenly distributed in time, so time gaps of more than 4 hours are possible

Product Summary

- SFR is liquid equivalent snowfall rate retrieved over land (with some visualizations that calculate solid rates)
- SFR uses observations from microwave sensors aboard polar orbiting satellites
- Ten SFR estimates a day grouped into 5 morning and 5 afternoon overpasses in mid-latitude; up to 5 times more in polar regions
- Most important applications:
  - Identify in-cloud snowstorm extent and area with the most intense snowfall
  - Fill gaps in radar coverage and ground observations
  - Cloud seeding for possible short-term forecasting

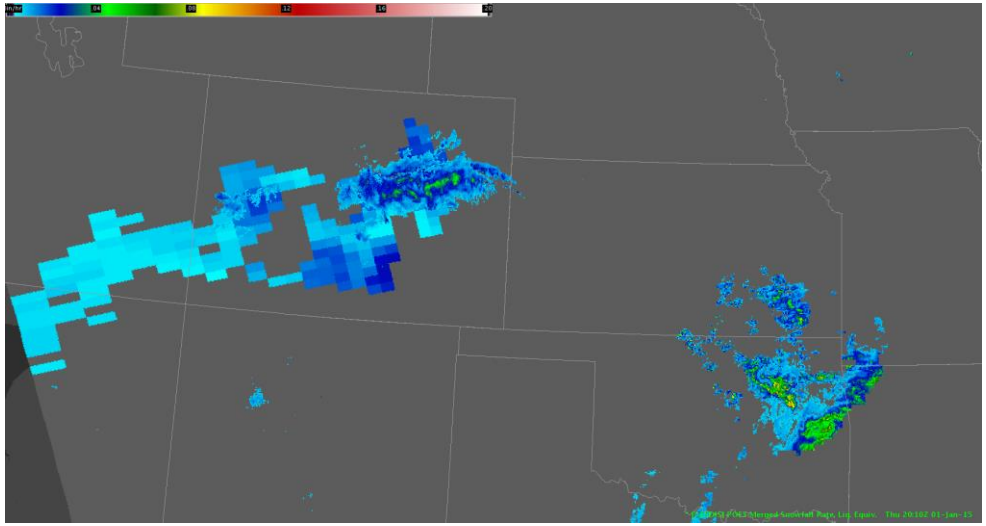
Radar and Satellite Merged SFR (mSFR)

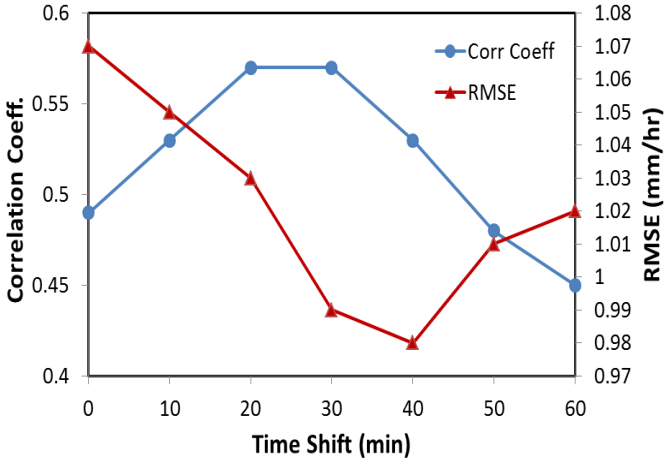
- Merging MRMS instantaneous snowfall product and SFR provide better spatial and temporal coverage and ability to loop the data (mSFR)



Radar and Satellite Merged SFR (mSFR)

- Specific features of the mSFR product:
  - SFR product is added where MRMS indicates radar data are of low quality or out of range (most useful in western U.S.)
  - In blended product, MRMS data are time lagged by 30 minutes to ensure product is viewing the same features (see figure below)
  - One image every 10 minutes to provide looping capability
  - CONUS only due to use of MRMS for radar data





Radar and Satellite Merged (mSFR)